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Risk Based Budgeting of Infrastructure Projects

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Abstract

Determining the budget is a fundamental process for the development of infrastructure projects for three main reasons: a) it establishes a cost baseline that integrates project scope and quality requirements along with sponsor's funding limits, b) it constitutes a performance measure during the whole project's life-cycle, and c) it affects the competitiveness of the bid. Budgeting and cost estimation methods vary in terms of complexity and accuracy, but, most important, in the way they address contingency reserves in the total budget. The aim of this research is to explore the most applicable budgeting methods for infrastructure projects with regard to the inclusion of risks related costs to the overall budget and demonstrate the capacity of stochastic processes for optimizing overall budgets. Case-based reasoning, multiple regression analysis, Monte Carlo simulation and deterministic methods are briefly presented in terms of theoretical approach, requirements, accuracy and integration of risks. Two prevailing budgeting methods, namely the deterministic and Monte Carlo simulation are applied on a real case of reinforced concrete works for a building project; the comparison of the results highlights the two major findings of this research: a) stochastic processes provide more accurate justification of the contingency reserves required for inclusion of risks in budgets of infrastructure projects, and b) stochastic processes are optimum for the definition of realistic contingency reserves that, in turn, results to more competitive bids. The research concludes with the suggestion that stochastic processes should be used for risk based budgeting of infrastructure projects.

Keywords: Infrastructure projects; risk; Monte Carlo; budgeting; bid

1. Introduction

Budgeting of an infrastructure project, even from the very early stages of implementation, is a crucial project development process. Despite of the shortcomings of limited data and unidentified uncertainties

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and risks, an early budgeting is always required, in order to provide a range of costs for the development of the project in combination with the initial quality requirements set by the project sponsor (Tas & Yaman, 2005). The analytic and detailed cost estimate of project works is fundamental at the design phase where most of the activities and considerations with cost implications need to be decided and agreed between the project's stakeholders (Wen-der, 2006). Cost estimations and determination of budgeting requirements is an iterative process that takes place, also, in the rest of the phases in the project's life cycle, i.e. execution, monitoring and control, and ending of the project. As the project evolves, cost estimations become more accurate, since they are supported by a greater amount of reliable data.

The need of accurate and updated data is imperative, in order to assess realistically the project's costs performance and budgeting requirements, however data are not the only requirement for reliable cost estimations; appropriate data processing and a systematic consideration of several implications is required, in order to result to accurate cost estimations. According to Koo *et al.* (2010), this can be achieved either based on a team of experts that possesses high quality knowledge on the field or based on appropriate cost estimation methods that can substitute such a team. Common practice proves that the use of cost estimation methods is related to the project's importance and magnitude including the amount of money involved, rather than the requirement for accuracy in estimations. While infrastructure projects, which in the context of this research extend to any type and size of infrastructure, including public and private construction projects of any potential use (residential, industrial, utilities, etc.) are of significant importance for their sponsor, the application of systematic cost estimation methods is not introduced except from cases that may present particularities (e.g. public-private-partnership projects). Moreover, risk reserves are determined either on an empirical or a regulatory manner as fixed amounts that correspond to a certain percentage of the overall budget (Touran, 2003). In this way, there is no rational estimation of risk reserves, which may have a critical impact on the potential of success during the tendering process; over-estimated risk reserves may lead to non-competitive offers, while underestimated ones jeopardize the unhindered development of the project.

This paper briefly presents well-established budgeting methods, which are applicable to any type of infrastructure construction projects focusing on the way they address risk contingencies to the overall assessments. Then it clearly demonstrates the necessity for introducing new approaches for the determination of risk contingencies compared to the current practice. The usual deterministic estimation of risk contingencies is compared to a simple application of a Monte Carlo model on a real case of reinforced concrete works for a building project. The results clearly demonstrate the capacity of stochastic processes to contribute to more realistic budget estimations and more competitive bids for contractors.

2. Budgeting Methods for Infrastructure Projects

There are several budgeting methods applied in the construction industry, which present significant differences in terms of philosophy and approach to the problem of estimating the budget for a project. The most applied are the deterministic ones, however more complex methods such as Case-Based Reasoning (CBR), Regression analysis and Monte Carlo simulation are also met in practice. In this section a brief overview on those methods is presented, in terms of theoretical approach, requirements, accuracy and integration of risks.

2.1. Deterministic Cost Estimation Methods

There are many deterministic methods that are being used currently, in order to estimate, with adequate precision, the budget of a project. Two of them, which are widely applied, are the Unit Quantity Method (UQM) and the Total Quantity Method (TQM).